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An Overview of SLAC Experiment E158: Precision Measurement of $\sin^2(\theta_w)$ away from the Z pole

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ABSTRACT

SLAC Experiment E158 is a precision measurement of parity violation in Møller scattering in which ~ 50 GeV longitudinally polarized electrons scatter off unpolarized electrons in a liquid hydrogen target. The resulting left-right parity-violating asymmetry is proportional to $(\frac{1}{4} - \sin^2\theta_w)$, where θ_w is the electroweak mixing angle. Experiment E158 will provide the most precise measurement to date of θ_w off the mass of Z^0 boson at a Q^2 of $0.003(\text{GeV}/c)^2$. This measurement will provide an important test for the Standard Model with TeV scale sensitivity to new physics. The predicted Standard Model asymmetry is $1.9 \cdot 10^{-8}$. The E158 goal is to measure this asymmetry to an accuracy of better than 10^{-8} , which corresponds to $\delta(\sin^2\theta_w) \sim 0.0007$. In our poster we presented an overview of the E158 experimental setup as well as our performance during the 2002 run.

1 Motivation

SLAC experiment E158 is an e^-e^- fix target experiment. A beam of longitudinally polarized (polarization $> 80\%$) e^- of 45GeV(or 48.3GeV) collides with a 1.5 meter long target of liquid H_2 (unpolarized). The produced interactions are mainly $(e^-e^- \longrightarrow e^-e^-)$ Moller scattering, $(e^-N \longrightarrow e^-N)$ elastic scattering and

($e^- N \longrightarrow e^- X$) inelastic scattering. The experiment goal is to measure the asymmetry in the cross section of the Moller scattering

$$A_{LR} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} \quad (1)$$

with a precision of 10^8 . In equation 1 $\sigma_R(\sigma_L)$ is the cross section for incident right(left) helicity electrons. In the Standard Model A_{LR} is due to the interference between weak and electromagnetic Feynman diagrams. At the tree, level for E158 kinematics (at a Q^2 of $0.003(\text{GeV}/c)^2$), A_{LR} is about $3.2 \cdot 10^{-7}$. Radiative corrections reduce it to about $1.8 \cdot 10^{-7}$. From A_{LR} one can extract $\sin^2\theta_w$. E158 goal is $\delta(\sin^2\theta_w) \sim 0.0007$, this gives unique sensitivity to new physics at the TeV level (compositeness, GUTs, extra dimensions, lepton flavor violation).

2 Experimental Challenges

The degree of precision desired requires: 1)large statistics (the goal is for 600 million pairs of pulses on target, each pulse of about $5 \cdot 10^{11}e$, from which $1/10000$ is detected). 2)An electron beam polarized source photocathode capable of produce high polarization with high electron intensity. 3)High beam stability, intensity jitter $< 1\%$, spotsize jitter $< 10\%$, position jitter $< 10\%$. 4) small beam helicity correlated asymmetries and differences in beam intensity ($A_I < 2 \cdot 10^{-7}$), beam position and angle ($\Delta_x < 10nm$), beam energy ($A_E < 2 \cdot 10^{-8}$). 5)precise electron beam monitoring devices, toroid resolution < 30 parts per million (ppm), beam position monitor resolution $< 1\mu m$ per pulse, energy resolution < 50 ppm per pulse. 6)stable liquid H_2 , density fluctuations $< 10^{-4}$ 7)A high flux-integrating calorimeter detector with resolution < 100 ppm per pulse, with nonlinearity $< 1\%$ and able to perform well after high radiation damage. 8)Compatible with PEP-II operation (BaBar collaboration experiment). 9)Theoretical predictions of eP elastic and inelastic asymmetries which are important backgrounds to our measurement.

3 Results from 2002 run

E158 had its first physics run in 2002, 6 weeks May-June. Approximately 250 million pulses were logged. We are performing a blind analysis (Moller asymmetry value randomly offset) which we expect to complete by the end of September 2002. We obtain a $\sigma_{A_{LR}} = .024$ ppm (stat). In table 1 we give electron beam delivery and monitoring performance and in table 2 the electron beam asymmetries and their contributions to the Moller asymmetry.

Table 1: *Electron Beam Delivery and Monitoring.*

	Final Goal	Run I (2002)
Beam Charge	6×10^{11}	6×10^{11}
Intensity Jitter	2%	.5%
Position Jitter	< 10%	5%
Spotsize Jitter	< 10%	5%
Energy Spread	.3% rms	.1% rms
Energy Jitter	.2% rms	.03% rms
Polarization	75%	85%
Target BPM x,y	$1\mu m$	$2\mu m$
Target BPM x',y'	$.4\mu rad$	$.1\mu rad$
Energy BPM	30 ppm	40 ppm
Target Toroid	30 ppm	60 ppm

Table 2: *Electron Beam Asymmetries.*

	beam A_{LR}	Contribution to Moller $A_{LR}(\text{stat})$	Contribution to Moller $A_{LR}(\text{sys})$
Intensity	340 ppb	5.7 ppb	3.4 ppb
Energy	5 ppb	2.6 ppb	<1 ppb
Position	15 nm	1.0 ppb	~ 1 ppb
Angle	.25 nrad	1.0 ppb	~ 1 ppb
Spotsize	.7 nm	2.5 ppb	~ 1 ppb
all		~ 7.0 ppb	~ 4 ppb

4 Future

E158 will run 6 weeks October-November 2002 and probably 6 weeks at the end of 2003, hopefully completing the experiment.